Integrating Fish into Seasonally Flooded Rice Fields: On-Farm Trials in Assam, India

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Abstract

In the State of Assam, floodplains cover 2.6 million ha of area that is traditionally rice growing. The ecosystem in the rice-growing areas has undergone major changes as a result of various developmental activities and adoption of modern farming technology. Rice fields were once the major source of fish for the rural farmers. There has been a sharp decline in fish population in rice field leading to a chronic shortage of fish in the State and a deterioration of the rice ecosystem. This paper describes two on-farm experiments for integrating rice cultivation and fish production with the intent of contributing to the understanding of how raising fish can improve rice yields, rice-ecosystems and farm incomes.

Introduction

Seasonal floodplains are generally used for cultivating rice. Catching fish from rice fields is an extensive system of fish production without control of fish population, sex and size (Diallo 1992). The State of Assam (located between 24°-28° N latitude and 89°50'-97°4' E longitude) has about 2.6 million ha of seasonal floodplains, which are traditionally rice-farming areas associated with fish trapping. The water remains for 4-6 months in these floodplains (Bhagowati et al. 1997) and serves as a breeding ground for fish.

Most of the rice farmers of the State are smallholders and have small ponds (Bhagowati et al. 1997), measuring 25-30 m^2, in their rice fields, locally known as *kon pukhuri* (Baruah et al. 1999a). These ponds are used to harvest rainwater for irrigating land during puddling for rice transplantation (Baruah et al. 1999a) and to trap the wild fish that enter with the floodwaters. These localized small ponds were once regarded as a promising source of fish. Over the last three decades, the rice-ecosystems have undergone major ecological changes due to construction of embankments along the sides of the river Brahmaputra and its major tributaries, construction of roads, town and country planning and technological innovations in rice farming. With intensification of modern rice farming, the farmers have changed their practices in terms of use of genetically modified varieties, pesticides and chemical fertilizers. Crop management practices have been impacting the floodplain ecology and its economy and the process of ecological change is still continuing. As a result, there has been a sharp decline in the fish population leading to a chronic shortage of fish in the State.

The rice-ecosystem is an agro-ecosystem, which is made up of many components. The agro-ecosystem structure illustrates two potential descriptors: system components and their interactions (Dalsgaard 1995). Fish is a major component of the rice-ecosystem, where rice and fish complement each other, utilize different ecological niches and function together. The change in the ecosystem has seemingly deteriorated the system components, especially the fish population, their ecological interactions, ecological sustainability and carrying capacity.

This paper describes integrated rice-fish systems and two on-farm studies with the intent of contributing to our understanding of how raising fish can increase farm incomes and improve rice yields and the implication of these farming strategies for the management of the rice-ecosystem.

On-Farm Study I

An on-farm trial was conducted in two consecutive culture seasons, 1995-96 and 1996-97, in central Assam in an area of 66.8 ha, impounded by village roads and owned by 109 farmers. The flood level in the rice field during July-November is 50-60 cm. The area had 70 ponds, measuring 30-1 400 m^2 with depth ranging from 1-2 m, owned by 70 farmers. The total area under ponds was 2.8 ha. The site was rain fed with an average annual precipitation of 2 000 mm.

While rice cultivation was done at the individual level, fish farming was operated as a communal activity as the flooded areas become common property with little scope of being bounded by individual farmers. The owners of the plots formed an Association. The farmers contributed to a common fund for the fish farming component. The Association agreed upon certain management interventions: (a) formation of an Association consisting of all the owners of the plots; (b) shift from fishing to fish farming in rice fields; (c) raising a common fund by contributions, based on the size of land holdings, for meeting the operational cost of fish crop; (d) sharing the benefits of fish crop on the basis of land holding and pond size; and (e) voluntary restrictions on fishing till the Association decided to harvest. Meetings of the Association were conducted regularly for any decision relating to the operation of the rice-fish system.

Farming methods

Banas (bamboo screens) were erected at the waterways, i.e., at the bridges and culverts, to prevent escape of farmed fish and entry of wild fish. Rice transplantation was completed in mid-July. Fish seed were stocked after 15 days of transplanting the last plot. Early fry of *Catla catla, Cirrhinus mrigala, Labeo rohita, Labeo calbasu, Hypophthalmichthys molitrix, Barbodes gonionotus* and *Cyprinus carpio* were released in the rice field at the rate of 20 000/ha with a 14:18:14:9:18:9:18 ratio. Ponds received 50 kg/ha of agricultural lime during plot preparation. Fertilization was done with cow dung and inorganic fertilizers as given in Table1. Feeding was done daily at two per cent of initial fish biomass with a 1:1 mixture of rice bran and mustard cake.

Ranjit, a high yielding semi dwarf variety of rice, was cultivated in all the plots. The culture duration was 120 days. The flood level in rice fields during the rice cultivation period ranged between 50-60 cm and water depth in the ponds ranged between 1-2 m. As the rice grains ripened the water level receded and the fish took shelter in the ponds. Rice was harvested by each farmer individually. The Association farmed the fish from the ponds with 0.5-1.0 m water within one month of the rice harvest.

Table 1. Liming fertilization and feeding schedule for rice-fish farming in central Assam.

Items	Quantity	Time of application
Lime (per ha pond area)	50 kg	Before stocking
Cow dung (per ha pond area)	100 kg	Monthly interval
Urea (per ha pond area)	10 kg	Monthly interval
Single super phosphate (per ha pond area)	8 kg	Monthly interval
Feeding (2% of initial fish biomass)	2 kg	Daily

Table 2. Results of the rice-fish farming with 109 farmers in central Assam.

Dimensions	Unit	1995	1996	1997
Rice yield (paddy area)	kg/ha	2 000-2 200	2 100-2 300	2 100-2 300
Average income from rice grain	Rs.	9 450	9 900	9 900
Fish yield (total area)	kg/ha	50-60	300-350	400-450
Average income from fish	Rs.	1 650	9 750	12 750
Carried over fish seed	Number	-	20 000	30 000
Average income from fish seed	Rs.	-	6 000	9 000
Equivalent rice seed	kg/ha	366.7	3 500	4 833
Irrigation for puddling	Number	50	50	59
Extent of indiscriminate fishing	Number	109	10	-
Attitudes				
Favorable	Number	-	59	89
Unfavorable	Number	-	50	20
Satisfaction with fish yield				
Satisfied	Number	60	82	98
Not satisfied	Number	49	27	11
Sense of belonging				
High	Number	-	76	97
Low	Number	-	33	12
Number of ponds (increased)	Number	70	70	80
Number of ponds expanded	Number	-	-	10
Total pond area	ha	2.765	2.765	3.335

Results

The results of the study are summarized in Table 2. Rice yield increased by 100-200 kg/ha over the year when only wild fish were trapped. Fish production increased from 50-60 kg to 400-450 kg/ha after the integration of fish farming with rice farming. In addition, stunted yearlings were produced from the rice fields. The seeds harvested were 20 000 and 30 000 in 1996 and 1997, respectively. Figure 1 shows changes in income derived from the rice-fish system in central Assam from 1995 to 1997.

The program also resulted in significant psychosocial changes amongst the farmers (Fig. 2). Unauthorized fishing in the rice fields completely stopped. The farmers developed a positive attitude towards participatory management (81.7 per cent) and a strong sense of ownership (79.8 per cent). A

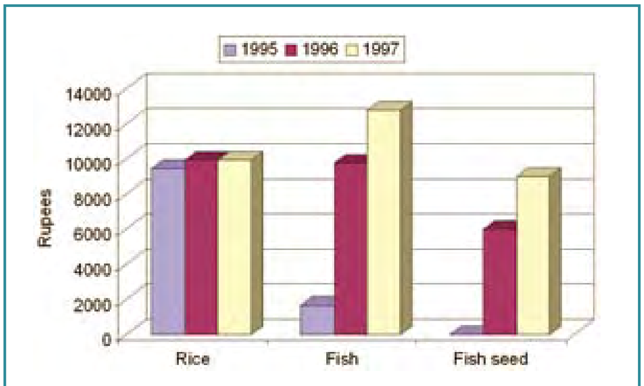

Figure1. Income trend in rice-fish system in central Assam.

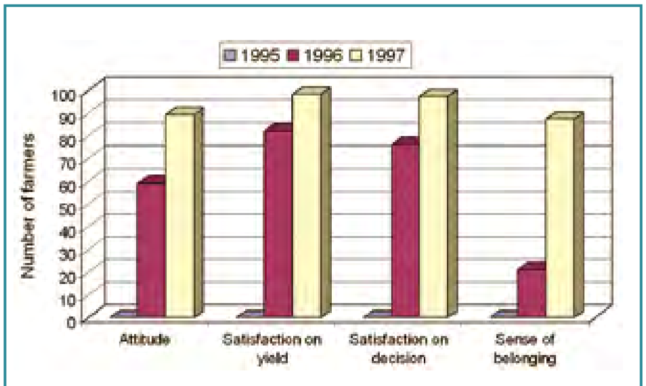

Figure 2. Psychosocial change after introduction of rice-fish system in central Assam.

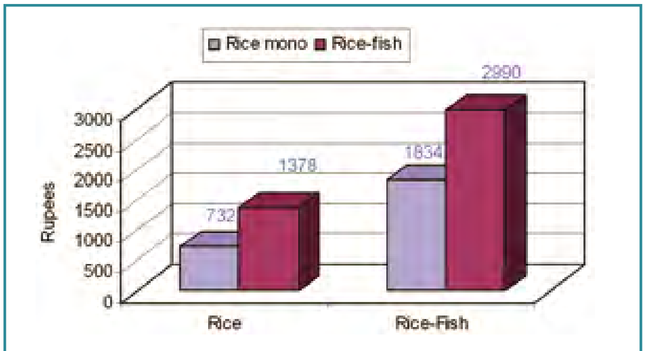

Figure 3. Cost and income of rice monoculture and rice-fish farming in upper Assam.

significant development was the creation of 10 new ponds and the expansion of 10 existing ponds. An increase in satisfaction with the decision-making process and fish yield was also observed. The total pond area increased from 2.8 ha to 3.4 ha in the third year.

On-Farm Study II

Another study was conducted over one year in upper Assam during 1996-97 in typical rice fields that are not flooded annually. A total of 50 rice-fish operating plots were selected in different villages employing the Participatory Rural Appraisal technique (Townsley 1996). The size of plots ranged between 0.07-0.14 ha. Another 10 rice plots owned by 10 farmers in different locations were selected for comparison. Data on inputs used, management practices, yields and operational costs were obtained from the beginning to the end of the culture operation.

Farming methods

About 10-20 per cent of the plot area (average 135 m^2) was utilized for the construction of dykes and refuge ponds/ditches and the remaining 80-90 per cent of the area (average 935 m^2) was utilized for rice transplantation. For both mono and integrated farming, a partial adoption of the recommended technology packages was observed in terms of varieties used, transplantation, plant protection, liming, size of fish seed and supplementary feeding. The farmers used different rice varieties and stocked with different species composition. Further, they did not feed the fishes at the recommended dose.

Results

The rice-fish system yielded 280.6 kg of rice grain and 479 kg of hay from the 935 m^2 area, while the calculated value for rice monoculture indicated that an area of 1 100 m^2 could yield 280.1 kg rice grain and 475.8 kg of hay. There was a 17.7 per cent higher yield of rice under the rice-fish system as compared to the non-integrated rice plots (Fig. 3).

Fish yield from trapping in the control plots was 2.3 kg/0.11 ha (20.5 kg/ha) and the average fish yield in rice-fish system was 55.1 kg/0.11 ha (501.1 kg/ha). The fish production from the rice-fish system was very minimal, which was attributed to poor management.

The average operational costs were Rs.1 834.1 and Rs.732.9/0.11 ha for rice-fish farming and rice monoculture, respectively, and the returns were Rs.2 990.3 and Rs.1 378.3/0.11 ha for rice-fish and rice plots, respectively (Table 3 and Fig. 3). The comparative analysis reveals an additional income of Rs.1 612/0.11 ha.

Conclusion

Rice is the most important cereal crop in Assam. The State currently produces 3.9 million t of rice and envisages producing 13.5 million t by the end of 2025 (Pathak 2001). A significant amount of work has been done for crop improvement, crop management and the development of rice varieties suited to specific stressed conditions. However, very little has been done so far to restore the rice-ecosystem and enhance its productivity.

Head of expenditure/income	Area Quantity/No.	Total cost/income (Rs)	Remarks
Inputs for rice crop			
Tilling	3 -4 times	201.10	
Rice seed	4 -7 kg	68.32	4 kg in case of high yielding varieties and 7 kg in case of traditional varieties
Farm yard manure	900 kg	300.51	
Urea	4.0 kg	20.34	
Single super phosphate	5.6 kg	42.71	
Murate of potash	1.5 kg	13.73	
Harvesting	-	96.50	
Cost of rice cultivation (Non integrated)	1 100 m^2	732.86	
Cost of rice cultivation (Integrated)	935 m^2	753.57	
Cost of fish farming in rice field	1 100 m^2		
Renovation of plot	235 m^2	263.74	10-20 per cent space of the plot
Fish seed (Number)	1 100	601.70	
Fish feed	10-15 kg	77.88	
Others	-	55.82	
Harvesting	-	81.60	
Cost of rice-fish farming	1 100 m^2	1 834.11	
Yield/income from non-integrated rice farming			
Rice grain	280.10 kg	1 190.43	@ Rs. 4.25/kg
Hay	475.82 kg	142.74	@ Rs. 0.30/kg
Fish (wild)	2.26 kg	45.10	@ Rs. 20.00/kg
Yield/income from integrated rice farming			
Rice grain	280.82 kg	1 192.81	@ Rs. 4.251/kg
Hay	479.47 kg	143.96	@ Rs. 0.30/kg
Fish (reared)	55.08 kg	1 653.51	@ Rs. 30.00/kg
Increase in income	-	1 612.00	

Table 3. Summary of yield and economics of rice-fish farming in upper Assam (per 0.11 ha unit).

Table 4. Comparison of growth of rice in rice-fish and rice systems. (Variety: Ranjit).

Parameter	Rice-fish system	Rice plot
Plant height (cm)	104.3	101.9
Tillers/plant (number)	16	12
Panicle/plant (number)	12	9
Grains/plant (number)	358	310

Fish plays a major role in the rice-ecosystem. It controls weeds and pests in the rice fields. It also reduces use of pesticides. Horstkotte et al. (1992) described rice-fish farming as an Aquatic Life Management (ALM) practice and opined that it can play a vital role as a vehicle for sustainable crop technologies such as Integrated Pest Management (IPM). Fish combat iron toxicity in rice by dibbling at the root zones and thereby help in releasing phosphorus to the water from association of iron. Phosphorus nourishes the blue-green algae that fixes nitrogen from the atmosphere and makes the soil fertile for the next crop. Moreover, the faecal matter of fishes is rich in nutrients, which are distributed evenly in the rice field by the fish.

Rice grows better in terms of height, tillers and panicles in rice-fish systems than in rice only systems (Table 4). A study conducted at the Fisheries Research Centre of Assam Agricultural University showed 48 grains more per plant in a rice-fish system than in a control plot (FRC 1998).

These observations clearly indicate that the income of the farmers can be doubled by effectively managing the rice-flood for rearing fish. Though the rice yield in the first study increased marginally (7 per cent), there was a 17.7 per cent increase in rice production in the second study.

The major constraints faced by the farmers in taking up rice-fish farming are security, apathy, poaching, input shortage, pests, disease and the lack of support services (Baruah et al. 2000). In contrast, added advantages are on creation of permanent infrastructure, which would significantly reduce the costs in subsequent years.

These studies indicate that the government should encourage the adoption of integrated rice-fish farming in the State through policy interventions. The lack of interdisciplinary communication limits the integration of research outcomes into the overall development program (Mitchell and De Silva 1992). The government should give policy support to the creation of opportunities for collaboration between various disciplines such as agronomy, soil science, hydrology, limnology, fisheries ecology and management, rice field engineering, pollution ecology and aquaculture (Mitchell and De Silva 1992). This will definitely have far reaching effects on the sustainability of the rice-ecosystem and increase the production of rice and fish.

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